DAVID SLS-1

Getting Started Guide

Version 3.9

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DAVID SLS-1

Contents of Package

- SL Scanner pre-mounted, consisting of
  - Video projector
  - Camera with focusable lens
  - Mounting rack with ball joint (for camera)
- Tripod with protective bag
- 2 pairs of calibration panels with 2 mounting tracks 90°
- USB drive with DAVID-Laserscanner Pro Edition and camera drivers
- Accessories for projector
  - External wall power supply
  - Remote control
  - VGA cable
  - HDMI cable
  - 2 AV cables (not required for scanner)
  - Protective bag
  - User Manual
- Adapter set for global power supply
- USB cable for camera
- Cable straps

System Requirements

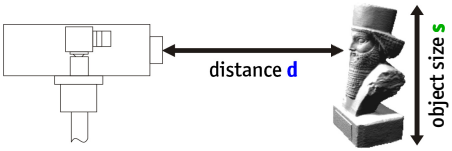
- Windows XP, Vista, 7 or 8 (32-bit or 64-bit)
- Microsoft .NET Framework 4.0 (32-bit), 4.5 (64-bit)
- 3D graphics adapter
- Available VGA or HDMI port
- Two available USB ports
- Recommended: Dual-core processor, 2 GHz, Windows 7 64-bit, 4 GB RAM, NVIDIA or AMD graphics card

Safety Instructions

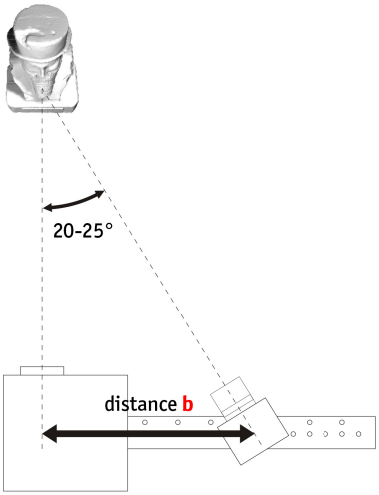
- Only operate the scanner in a dry environment.
- Do not operate the scanner in areas where there is a risk of explosion.
- Repairs to the scanner or its components may only be performed by an authorized service centre or the DAVID-Laserscanner after-sales service.
- Do not make changes of any kind to your scanner.

Preparation

Setup



(side view)



(top view)

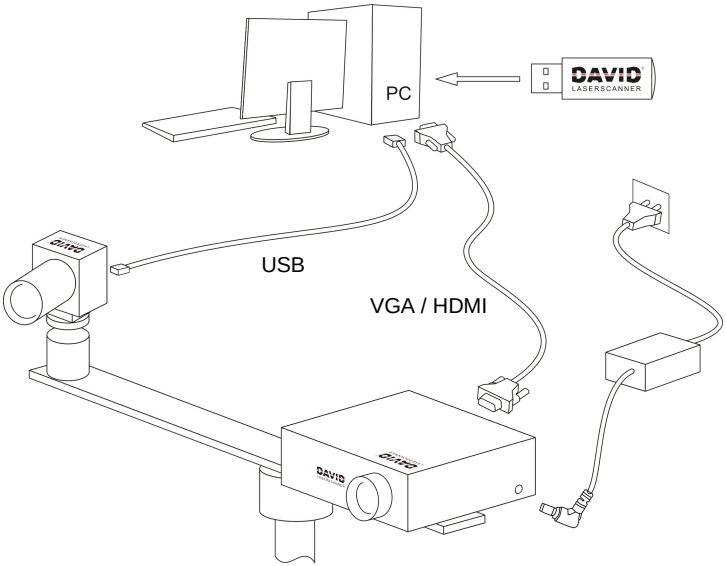
Before connecting the devices, adapt the whole scanner setup to the size of the object or surface region you want to scan.
The intersection angle between projection and camera view should be around 15°-25° (max. 10°-35°).
The following table should give you some indications for an optimal setup:

Size of scan object / surface region s	Calibration pattern	Lens distance b between camera and projector	Distance d between scanner and object	Achievable scan resolution (approx. 0.1% of object size)
<30 mm	30 mm	ca. 60 mm	ca. 90 mm	< 0.05 mm
50 mm	60 mm	ca. 60 mm	ca. 120 mm	ca. 0.05 mm
70 mm	60 mm	ca. 65 mm	ca. 180 mm	ca. 0.08 mm
90 mm	120 mm	ca. 80 mm	ca. 220 mm	ca. 0.1 mm
120 mm	120 mm	ca. 110 mm	ca. 300 mm	ca. 0.13 mm
150 mm	120 mm	ca. 125 mm	ca. 350 mm	ca. 0.15 mm
200 mm	240 mm	ca. 160 mm	ca. 450 mm	ca. 0.2 mm
300 mm	240 mm	ca. 250 mm	ca. 700 mm	ca. 0.3 mm
500 mm	240 mm	ca. 400 mm	ca. 1200 mm	ca. 0.5 mm
in general	similar to object	angle 15°-25° between them	object should fill camera image	ca. 0.1% of object size

The camera can be mounted left or right of the projector – depending on how a suitable distance between their lenses can be achieved. The DAVID software also supports a vertical setup, with camera and projector above each other.

Installation

Connect all components as depicted below:



Installation of the Camera Drivers

Even if Windows automatically installs drivers, we recommend to install the included drivers:

1. Plug the USB drive into your PC, then choose “Open” resp. “Explorer”.
2. Launch “Install_SLS-1_Camera_Driver“ (may require administrator rights).
3. Follow the instructions on screen.

Projector Settings

The projector is shipped with optimal settings. We recommend not to change anything in the projector's on-screen menu.

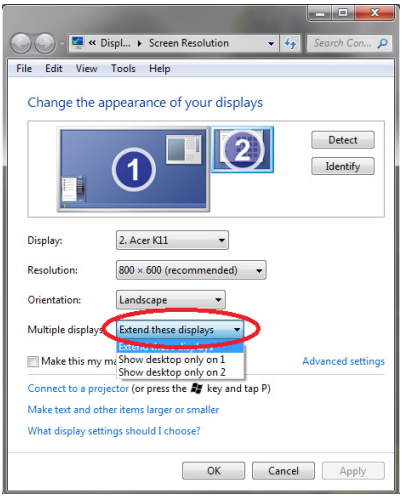
You can restore the recommended settings in the projector's on-screen menu any time:

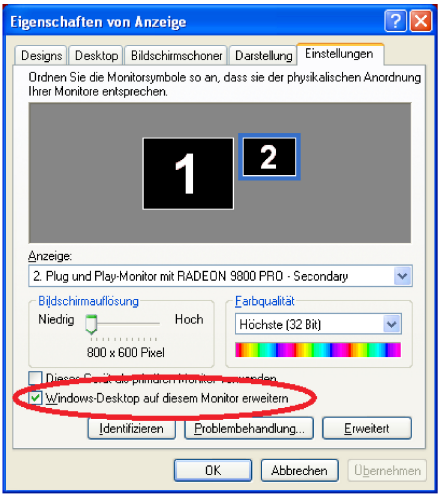
1. Select “Reset“
2. Be sure to switch “Auto Keystone“ OFF, and set the Manual Keystone value to 0.
3. As “Projection Location” choose the symbol for table placement.

For more information, please refer to the projector's User Manual.

Setup Projector as Extended Desktop in Windows

With your right mouse button, click on a free space on your Windows desktop. Choose “Resolution” or “Properties” (depending on your Windows version).





In this dialogue window, you can separately change the settings of your two displays, monitor and projector.

Your monitor should be set as “main display”. Set the projector to be an extended desktop (“extend these displays” / “extend desktop to this display”).

This setting is required so that DAVID can project its scan patterns and show the user interface on your computer screen at the same time. You can find more detailed instructions in our online user manual at http://www.david-3d.com/ , “Manual”, in chapter “3D Structured Light Scanning“.

When these settings are correct, your monitor and projector will show different contents (but with the same desktop wallpaper). You can move the mouse pointer sideways from the monitor into the projected image. The Windows Taskbar and most desktop icons will be shown only on the monitor. All windows can be moved from monitor to projector, and vice versa.

If the DAVID main window is shown on your projector, grab its title bar with the mouse and move it over to your monitor.

Furthermore you should make sure that the projector frame rate is set to 60Hz. Select the projector, click “Advanced settings”, open the “Monitor” tab, there you can adjust the frame rate to 60Hz.

Scanning with DAVID

Launch DAVID by starting “Start_DAVID3“ or “Start_DAVID3_x64” on your DAVID USB key.

On the left side you can see the expandable main menus. Each menu is dedicated to one of the following work steps, which you will usually walk through from top to bottom.

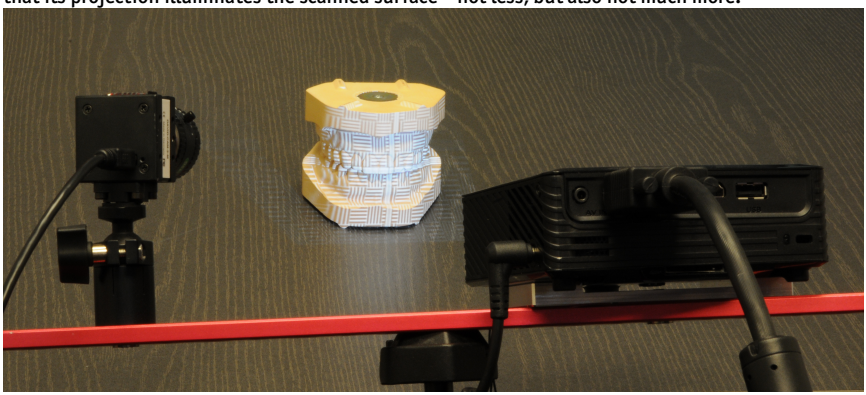
Our software is developed and improved continuously. Therefore, please use the automatic update, or download and install updates manually from our website http://www.david-3d.com/. All updates within versions 3.x are free of charge.

This printed manual refers to version 3.9 of the software and may already be out of date. Please also read our detailed and always up-to-date online manual, which you can find on http://www.david-3d.com/.

Calibration of the Scanner

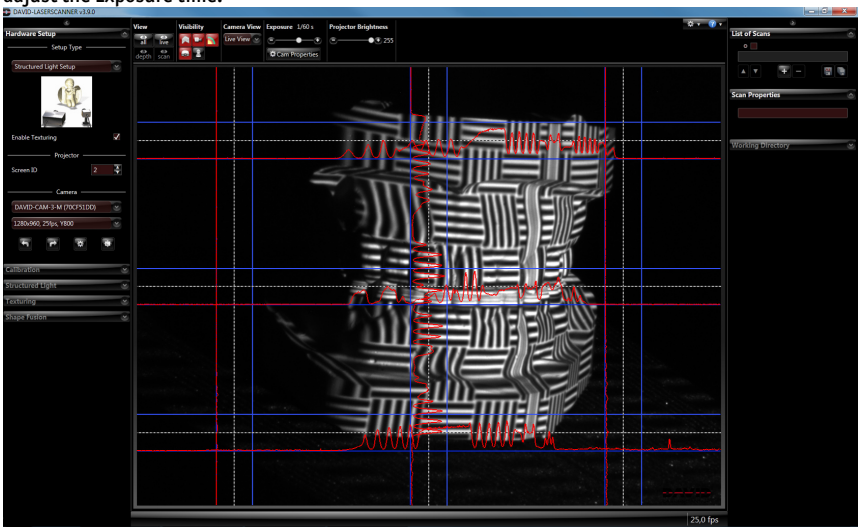
One advantage of the SLS-1's modular setup is that its size can be adjusted to very different object sizes. Therefore, calibration (measurement of the current hardware setup in the DAVID software) is required, allowing the software to obtain undistorted 3D data at the correct scale. We use a calibration corner as reference, whose properties are known precisely.

1. Menu “Hardware Setup“: Adjustment and settings of projector and camera
    1. Select setup type “Structured Light Setup“.
    2. Choose the correct “Screen ID“ such that the stripe pattern is projected by the projector.
    3. Place the scanner in front of the scanned object and adjust the projector's position and direction so that its projection illuminates the scanned surface – not less, but also not much more.

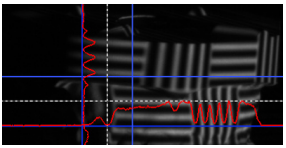


    4. Use the projector's focus ring to adjust sharpness, such that the black and white stripes are *almost perfectly* focused on the object surface. If the projector is perfectly focused, the fine lines between the projector's pixels may cause a fine noise in the scan, so we recommend to set the projection *slightly* out of focus. This will not reduce the scan quality.
    5. Below “Camera”, select your camera (DAVID-CAM-3-M). You will see the live view. If necessary, roughly adjust the camera's mechanic aperture and focus ring.
    6. Aim the camera so that it can see the projected pattern on the object. Then fix the ball joint.
    If the camera view and/or projector beam obtains much more than the scanned surface, you should reduce the distance between scanner and object (step 3).
    7. The Exposure Time should be set to the same value as the projector frame rate (usually 1/60s),

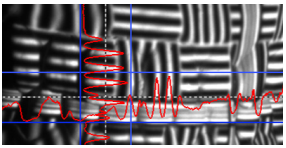
otherwise the camera image might flicker or pulse when looking at the projection. If it flickers, adjust the Exposure time.



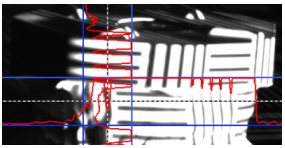
8. The “Projector Brightness” control should be at maximum in most cases. Only reduce it if a clean, undistorted sine wave cannot be obtained otherwise.
   Adjust the mechanic aperture at the camera's lens. Regard only those image regions that show the wave patterns: The red intensity curves must be sinusoidal and must not be over- or under-saturated. In other words, the red sine curve must not be cut off at the blue borders.



Too dark.
→ Increase aperture size



Perfectly adjusted,
sine wave nearly reaches the blue borders.



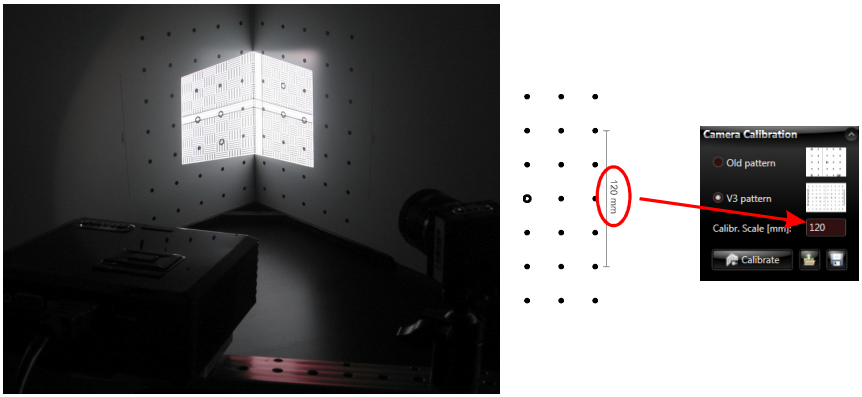
Too bright,
Sine wave is cut off (overdriven).
→ Decrease aperture size

Note: You can see a scale at the camera's aperture dial, ranging from 16 to 1.4. Even for very bright situations (small object), you should not set it above 16 because that would reduce sharpness. Instead, if necessary, please reduce Projector Brightness.

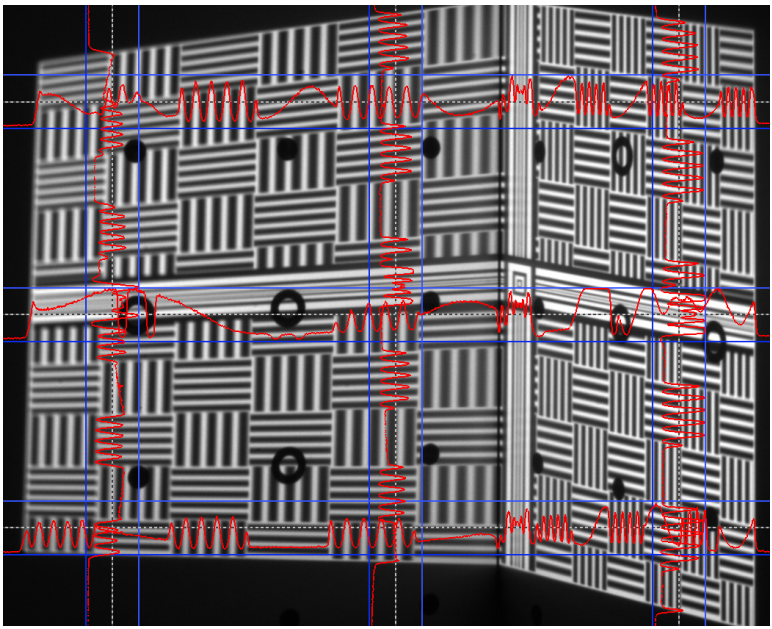
9. Look at the object in the camera image. Adjust camera focus (mechanic focus ring) so that the object and the projected black&white stripes are depicted as sharp as possible.
10. Fasten all screws (projector, ball joint of camera) so that nothing can be dislocated from now on. The scanner is now optimized for your object (size of scan region, working distance, surface brightness) and has to calibrated like this.

2. Menu “Calibration“

1. Select a calibration pattern size which fits to the object (see table on page 3). Set up the calibration corner at precisely 90°, using the mounting tracks. For starters, the pattern should be flapped to the inside, while advanced users may be able to reduce reflections with a concave corner setup.
2. Remove the object and set up the scanner and the calibration corner in front of each other, with approx. the same distance as the object before. The projection and camera image should be well focused.
   The camera image must show at least the 6 ring markers and a few dot markers. The whole camera image should be filled with around 15 to 70 calibration markers, and the camera should not able to look past the calibration boards.
   You can move, rotate and tilt the scanner as a whole, but you should not change anything above the red mounting rack.



3. Enter the scale size of the calibration pattern at “Calibr. Scale”. You can find the number printed on the panels right next to the respective pattern.
4. Check the camera image again. In those areas that show the wave patterns, the red intensity curves must not be cut off at the blue borders.
   If the scanned object is significantly darker than the white calibration panels, the sine waves will be distorted now. Temporarily reduce the “Projector Brightness” slider to correct this.
   The camera image should look approx. like the following:



5. Click “Calibrate” in order to calibrate the whole scanner.
   In this step the software will first measures the position, orientation, focal length and distortion coefficients of the camera. Then it will project a pattern sequence in order to determine the same optical properties of the projector. If Texturing is not switched off, it will also project different colors to perform a white balance measurement.

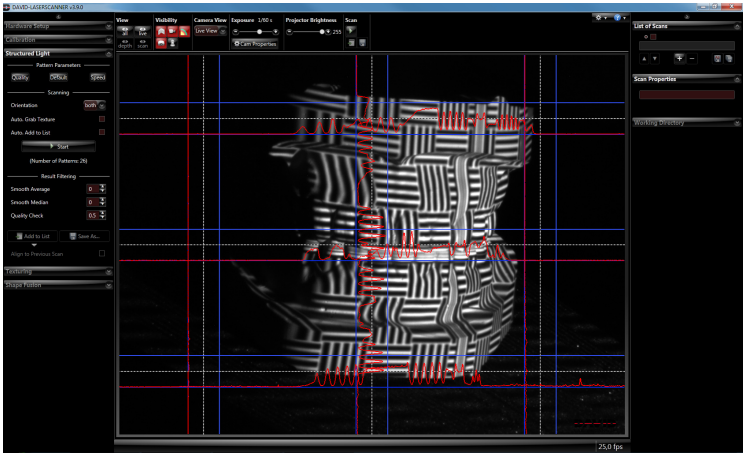
After a successful calibration, DAVID will project a checkerboard pattern, whose corner points should fall exactly onto the calibration markers.

Your scanner is now calibrated. This refers to the position and orientation of camera and projector relative to each other, and the focus and brightness settings. You may move, rotate and tilt the scanner as a whole, and you can close and restart the DAVID software, without losing the calibration. You may also change the Projector Brightness setting in order to adjust image brightness (red sine curves) to the scanned object.

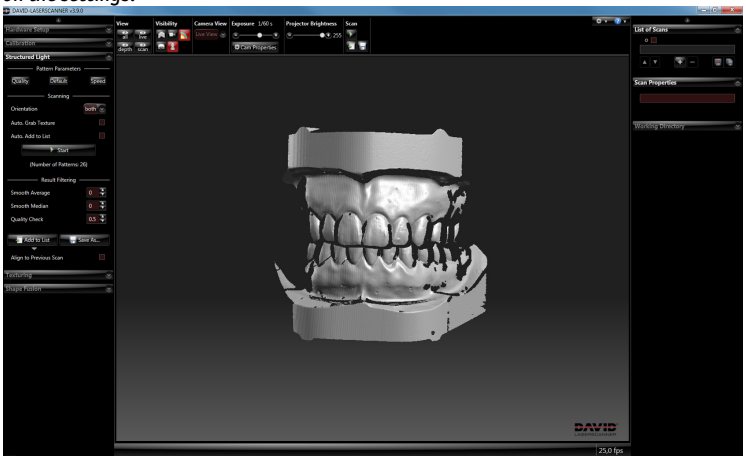
However, if you rotate camera or projector with respect to each other, or change the focus (e.g. in order to scan much smaller or larger objects), you will have to repeat the whole calibration procedure.

3D Scanning

Menu “Structured Light“



- Place scanner and object in front of each other, at the same distance like you did during calibration. If the distance is too different, the projected stripes and camera image will be out of focus. A *slightly* unsharp pattern projection is even desirable, but the camera should be perfectly focused. If necessary, correct the distance between object and scanner, but do not adjust the focus rings.
  Important: For each scan, observe that the red sine waves are not cut off / overdriven (this refers only to the image regions where the wave pattern is visible). Should a correction be required, adjust the “Projector Brightness” slider.
- Each click on “Start” performs a new scan.
  DAVID projects a set of stripe patterns and records the images. This takes 2-4 seconds or more, depending on the settings.



- If you check the "Auto. grab texture" option, DAVID will record a texture with each scan. If the texture is too bright or too dark, you can adjust the texture settings in the Texturing menu (see below).
  With the corresponding Visibility button at the top bar, you can choose whether the texture will be shown in the 3D view.
- With your mouse, you can rotate, move and zoom the 3D view.
- The scans need to overlap sufficiently so that they can be combined/aligned later on. Generally, 6-8 scans of different views around an object are required, plus possibly a few of the top and bottom sides. Grabbing a texture with each scan can help with the automatic or manual alignment.
- Using the Smooth options under "Result Filtering", you can smooth the 3D data of your scan. However we recommend not to do this (keep Smooth settings at 0). Instead, if your scans are noisy or wavy, you should optimize the scan conditions (brightness settings, room conditions).
  More options for smoothing can be found in the Shapefusion menu.
- The "Quality Check" setting removes scan data that are probably imprecise, which can happen at scan border or between dark and bright surface regions. You can adjust the value and watch the effect immediately. Recommended value is 0.5.
- Save each successful scan as an OBJ file ("Save As") and/or add it to the List of Scans.
  After each click on "Add to list", you can immediately align the new scan to the previous ones (Shapefusion menu, see next chapter). Alternatively, you can first collect more scans in the Structured Light menu, and align them all later.
- When all settings are optimized and you are making many scans in a row, you can simplify the process by enabling "Auto. Add to List" and/or "Align to Previous Scan". This is recommended only for experienced users.

Menu "Texturing"

You can record a texture with each scan. Since the SLS-1 contains a monochrome camera, DAVID will project several colors with the projector and measure the respective reflections from the object surface with the monochrome camera. From these data DAVID can compute a real color texture.

Texturing may require different illumination settings. When the Texturing menu is open, you can adjust Projector Brightness, camera Exposure or other camera properties as you like, without influencing the scan settings. A decent texture is like a good photo: uniform illumination, not too bright, not too dark. The projected color stripes should be visible in the camera image as bright gray (not too dark but also not white) stripes.

In some cases it may be helpful not to use the projector as a light source (set Projector Brightness to 0), but instead use diffuse environment light in the room. However, in that case the monochrome camera can only record a gray-scale texture.

White Balance: Each time you have changed settings, you should perform a new White Balancing. *DAVID will calibrate the color properties of the whole system (camera, projector) in order to measure accurate colors of the object later.* White Balancing requires the camera image to show nothing but a big white object (e.g. the calibration corner or a white wall).

- The button "Grab Texture" records a new textures and applies it to the scan at hand.
- All settings here are stored separately. For the following scans, you will not have to open the Texturing menu each time. Instead you can use the "Auto. grab texture" option in the Structured Light menu.

Alignment and Fusion of Multiple Scans

Menu “Shape Fusion“

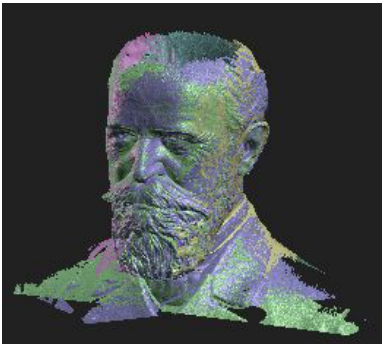
This menu offers 1. to align several scans to each other and 2. to fuse them into one closed 360° model. You can export the fused object in various file formats and use it e.g. for 3D printing. In the following we describe the general case of aligning scans from arbitrary perspectives. Hints about special cases and more detailed information can be found in the online manual on www.david-laserscanner.com.

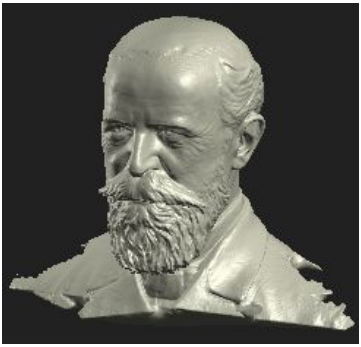
1. Scan Alignment
   - Single scans are usually collected in the List of Scans using the “Add to List” button during scanning. You can also import scans from OBJ files by drag-and-drop or with the “+” button below the list.
   - Hint: Each scan can be toggled visible/invisible with the button.
   - If necessary, you can clean your scan with the Selection Tool. At this time you should only remove surface areas which are not useful for alignment, i.e. which no pair of scans have in common.
   - Hint: With the Arrange buttons you can arrange all scans next to each other in order to get a good overview.

   - DAVID offers several alignment modes. In general you should start with the “Free” mode, which aligns one scan to one other with each step. In order for the automatic mode to find the correct alignment, the scans have to overlap sufficiently, i.e. contain a good portion of identical areas.

     The button starts the alignment mode. In the 3D view, first click on the scan you want to align, “Scan A”. Then click on the scan you want to align it to, “Scan B”. These images show an alignment of the blue scan to the green one:

     Subsequently, align more scans to those previously aligned. Always select pairs which overlap as much as possible. In the example shown above, a good next step would be to align the yellow scan to the blue one, and so on.
   - After all scans have been aligned, you should run the “Global Fine Registration” mode.

- 



Scans after Alignment *Fusion Result (with "Close Holes")*

- Hint: All scan movements can be undone separately with the "Undo" button .
- Hint: In case the automatic alignment does not find the right solution, you should activate "Contact Pair Selection". Subsequently you can help DAVID: When you click on the scans you want to align, click precise at distinctive surface areas (e.g. tip of the nose) which are supposed to be in contact. The size of the red circle next to the mouse pointer is relevant. If you wish to click on the contact points very precisely, zoom in first. If you cannot click the contact spots precisely, zoom out so that the red circle covers a larger area.
- Hint: You can save your single scans at any time. They will be saved in their current position and rotation in space, so you won't have to align them again. Use the save buttons below the "List of Scans".
- Hint: After some alignment steps it can be helpful to "combine" several scans temporarily. Select two or more scans in the List of Scans (check marks). Then click on them with the right mouse button, and choose "Combine". This puts the selected scans into one group temporarily and allows you to tread them all as one. In our example, the Büssing bust, we might combine scans 1 and 4 and then align scan 5 to that group. This way scan 5 would be aligned to both scans at the same time, which includes more overlapping areas and thus can lead to a more precise alignment.
  Right-click on the group's name in the list and choose "Uncombine" to separate the group again.

2. Scan Fusion

- Only visible scans will be fused, so select all scans with the button above the list.
- Increase "Resolution" carefully. This will increase computation time and memory consumtion.
- "Refinement" can improve precision and details in some cases, but it often causes artifacts. Please test if it helps for your scans.
- Click "Fuse" to start the Fusion. This is a complex process which requires a computation time of several seconds or minutes. All visible scans will be merged to one closed triangle mesh, removing small artefacts. If the scans have textures, a fused texture will also be created. Optionally, all holes will be closed.
- Finally you can use the "Save" button to export your fused 3D model as OBJ, STL or PLY file.

Terms of Warranty

This device was manufactured using the latest production methods and has been carefully inspected. All DAVID Laserscanner® products are subjected to rigorous quality control. If this device nevertheless fails to perform faultlessly, this is something we regret and we ask you to consult your supplier.

The following conditions apply to warranty claims:

This warranty is valid for a period of 24 months from the day of purchase. Please keep the receipt carefully as proof of purchase when making a warranty claim.

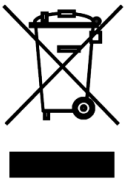
The defective product may be returned to your supplier during the warranty period. If the warranty claim is valid you will be entitled to the repair of your device or a new device will be given to you. This is free of charge. Alternatively a warranty claim can be settled through reimbursement of the purchase price. After the warranty period has expired you still have the option of sending the defective device to your supplier or to the DAVID Laserscanner® after-sales service for repair. Repairs made after expiry of warranty will be subject to a charge. Your statutory rights are not affected through this warranty.

Damage caused through improper handling, use, storage, changes to the electronics, lens or housing, or through Acts of God or other external influences or any operation outside of the technical specifications are not covered by this warranty.

Before returning the device please contact your supplier to ensure your warranty claim is processed as efficiently as possible. If it is not possible to process your warranty claim through your supplier, you may as an exceptional case contact the DAVID Laserscanner® after-sales service directly.

Disposal / Recycling

Waste batteries or accumulators may not be disposed of as household waste. Every consumer has a statutory obligation to properly dispose of these items at officially designated points of disposal. Never discard electronic components of the DAVID Laserscanner in standard household waste. In accordance with the EU Directive 2002/96/EC on waste electrical and electronic equipment this must be disposed of in accordance with local regulations. You can dispose of the product at your local public point for collection of electronic waste.



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